results cannot be obtained. The mean of ten determinations gave, for my right arm, $a = 1{\cdot}50$ kgr. The mean of twenty determinations likewise gave $a = 1{\cdot}50$ kgr., with a probable error of 0·01 kgr. Calculating from (6) the values of W for the different values of w, and co-ordinating these two quantities, and it is plain that the function is hyperbolic. It was found that W did not vary inversely as $(w + a)$, or as any power of this quantity.* The equation

$$(w + a)\,h\,n = \frac{c}{w^v} \qquad (7).$$

was then assumed, where c and v are constants to be determined. From this we readily have

$$\log.\,(w + 1{\cdot}5) + \log.\,n = k - v\log.\,w,$$

which is of the form

$$y = k - v.x,$$

where y and x can be calculated from the observations. Co-ordinating these values of y and x, and the curve is found to be linear, and we find v, as the change in y for each unit of change in x, to be 2·007. Hence Eq. (7) becomes

$$(w + a)\,h\,n = \frac{c}{w^2} \qquad (8).$$

Calculating now the values of a and c by the method of least squares, we find $c = 4261$ and $a = 1{\cdot}52$. The difference between a (calc.) and a (obs.) is only 1·3 per cent. of a(obs.) Solving (8) for n, and substituting the proper values, and we have n (calc.), as given in Table II. $d\,n$ is the difference in per cent. of n (obs.) Column e is the probable error of n (obs.), also in per cent. The comparison between n (calc.) and n (obs.) is shown graphically in Fig. 3, the observations being represented by the small circles.

Soon after arriving at Eq. (8), Prof. Haughton's book came to hand, containing his reduction resulting in Eq. (5). As already shown, this equation does not represent my later and more accurate observations. In order to test the matter still further, experimentally, the following experiments were made :—

1. I lifted my right arm from a vertical to a horizontal (h = 0·71 cm.), the experiments being conducted exactly as in the case of those given in Table II. The arm was lifted 2,000 times without feeling any appreciable exhaustion. According to (5), when $w = 0$, complete exhaustion should occur when $n = 1{,}000$. According to (8) it should occur when $n = \infty$.

2. A weight, $w = 0{\cdot}5$ kgr., was lifted in the same manner, and the arm allowed to drop with the weight during the interval of rest, as in case of my earlier experiments. It was thus lifted 1,500 times with very little exhaustion. According to (5) complete exhaustion should occur when $n = 400$. According to (8) n should be 12,000. This would make the total time of exhaustion 8 hours and 20 minutes. The total mechanical work would be 16,800 kgr. metres. The daily labour of a working man is about 100,000 kgr. metres. From estimates based upon this fact, and from the slight fatigue felt in the second experiment, I am convinced that my arm, at its mean strength, could work for $8\frac{1}{3}$ hours at the above rate, if the experiment were conducted as described above, care being taken to eliminate the fatigue caused by standing on the feet, &c. It would, however, be a highly dangerous experiment.

It will be remembered that each value of n (obs.) in Table II. is a mean of ten independent determinations. It occurred to me to co-ordinate the originally observed values of n with the daily determination of strength c. The result was most instructive. Each value of w gave a curve which is really parabolic, but which—since one of these curves ($w = 5{\cdot}0$) was taken as a unit in which to represent the others—appeared here as a straight line, or very nearly so, with exception of those which had been before rejected in calculating the constants. The reason for the great value of n for $w = 2{\cdot}5$ (Table II.) is thus apparent.

This at once opened up a new field—the relation of strength to work. In the investigations here the strength is determined by a spring balance, so arranged that the arm is held horizontally and the strain exerted upwards. Calling s the reading of the dynanometer, and the strength is $(w + a)$.† Co-ordinating, for the different weights used in Table II., the strength with the work done before exhaustion, and we have for each value of w a curve which is apparently parabolic, intersecting the axis of abscissæ (strength) at a point just inside the point where $s + a = w + a$.* As w diminishes, the curves increase in steepness with great rapidity. Eq. (8) shows the relation between the points on each of these curves, which correspond to my mean strength.

This opens up a way of estimating the statical work of a muscle, a problem which has been in view from the outset. We will take as the unit of statical work, the *kilogram-second*, or the work done by a muscle in sustaining for one second a strain of one kilo. exerted at right angles to its line of contraction. If now the same weights be used in exhausting the horizontally outstretched arm, we shall have by co-ordinating the work (in kgr.-sec.) with the strength, a system of curves as in the case of dynamical work. Accurate values of the constants for these curves have not yet been obtained, and we therefore will not discuss them further here. For each weight, co-ordinate the dynamical with the statical work, and it is readily seen that the relation between them can be made out, so that—given the total energy of a muscle in kgr.-sec. with any weight, and we can calculate the dynamical work in kgr-metres which this same muscle could do with this same weight. I intend to determine as accurately as possible the values of the constants in the cases heretofore discussed in these papers. I shall also thus investigate the effect of variation of the angle of elevation of the arm on the dynamical and statical work, including the case of statical work where the angle of elevation is zero : also the dynamical work, where the strain on the muscles is *continuous*, and (1) where the strain on the muscles (a weight) is constant, and the velocity of motion uniformly varied ; (2) where the velocity is constant, and the weight uniformly varied ; and (3) where both weight and velocity are constant. Making in this latter case, $v = o$, and we have the case of statical work. The apparatus necessary for this investigation has been already devised. FRANK E. NIPHER

* The equation $(w + a)\,h\,n = \dfrac{c}{(w + a)\,2{\cdot}63}$ will represent the observations, but it is a highly improbable relation

† $(s + a)$ is really the highest tension attainable by the muscle in exerting a uniformly accelerated force, with a uniform velocity through the space moved over by the hook of the dynanometer.

* My left arm is about five-sixths the strength of the right. Each varies greatly from day to day. Several other persons, the length of whose bones approximated my own, have been experimented upon. The co-ordinated values of work and strength are continuous with my own.

SCIENTIFIC SERIALS

Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie, Dec. 15.—To this number Dr. Prestel contributes an article on lines of cirrus as a means of foretelling storms. Storm signals he presumes to be inadequate for warning sailors of an approaching gale. He has compared during last year the indications of cirrous streaks with the weather shown by the charts to be prevalent on each day when his observations were made. From all the instances in which the streaks were well developed, he comes to the conclusion that the currents of the upper air do not follow the law of Buys Ballot ; that is, that in the region of cirrus the air has neither a cyclonic nor anticyclonic movement, but streams from the point of highest pressure in the area of high pressure to the point of lowest pressure in the area of low pressure.—Herr Köppen, having remarked the tendency of cyclones to follow closely upon one another, gives a table for Northern Russia of the intervals which most commonly separate them. Of 107 cyclones, occupying 393 days in the territory, 33 per cent. came in less than twenty-four hours after their predecessors ; 32 per cent. after an interval of one day ; 19 per cent. after two or three days ; 19 per cent. after four, five, or six days ; and 18 per cent. after seven, eight, nine, or ten days.—The observations of MM. Fautrat and Sartiaux, by which it appeared that more rain fell within than without the forest of Halatte, are objected to on account of the disturbing influence of wind, which blows less stongly at the one position, six metres above tree-tops, than at the other, fifteen metres above the plain.

Reale Istituto Lombardo. Rendiconti : vol. vii. fasc. ix., xi.—The first paper is On variations in the temperature of Milan, by Giovanni Celoria. Meteorological observations were commenced at the Observatory of Brera in 1763, and have been carried on without intermission, and show regular and irregular variations. The maximum temperature follows the culmination of the sun, and shows an oscillation in time of seventy minutes, being at 2h. 4m. in January and at 3h. 14m. in July. The minimum temperature in summer is eight minutes before the rising of the sun, and in winter forty-nine minutes before sunrise. This variation is less at Milan than elsewhere. The author follows Dove in dividing the year into seventy-three periods of five days each. There are two periods of medium temperature in the year, April 15 and 16, and October 18 ; 179 days are colder and 186 hotter

than these. May shows no regular retrogression of temperature, as in northern countries, though it is more variable than other months, and there is no Martinmas summer in autumn; thus confirming the doctrine that the Alps divide Europe into two meteorological regions. There are also variations coincident with the periods of sun-spots. Thus, from 1763 to 1768, from 1812 to 1817, from 1829 to 1838, from 1855 to 1858, the annual temperature was lower than the average; while from 1769 to 1772, from 1778 to 1781, from 1790 to 1794, from 1796 to 1798, from 1824 to 1828, from 1861 to 1872, excluding the years 1864 and 1871, the temperature was constantly higher.—The next paper is by Prof. Gaetano Cantoni, On the direct assimilation of nitrogen from the atmosphere. Having compared the production of corn and clovers, the author concludes that the Leguminosæ can absorb nitrogen from the air, but that Graminæ have not this power.—Prof. Tullio Brugnatelli and Dr. Pelloggio publish the results of their examination of the mineral water of Monte Alieo. It is sulphurous, and will keep for months in sealed bottles, but ultimately develops Cryptococcus brumes. Its temperature is 13° C.; it smells like a saturated solution of sulphuric acid, but is not unpalatable. A litre gives a solid residue of 3·96 grains, chiefly formed of chloride of sodium and sulphates of magnesia and lime.—Prof. Leopoldo Maggi contributes a note On the distinctions introduced in spontaneous generation, and defines clearly and adopts the terms agenia, necrogenia, and xenogenia, introduced by Milne-Edwards, and suggests that agenia may be divided into inorganic and organic agenia. At the reading of this paper, Prof. Sangalli remarked that he found long Bacteria and Micrococcus in an ulceration in the throat, and the same organisms in a diseased stomach.—The next paper is by Prof. Achille de Giovanni: Clinical and anatomical observations concerning the pathology of the sympathetic system; in which his researches respecting the infiltration of the intercostal ganglia are continued. In a former paper he attributed the infiltration to the growth of numerous adventitious vessels, but in a section of a ganglion hardened in a solution of bichromate of potash the presence of a very fine connective tissue is easily seen to accompany the nerve-tubes and involve the ganglia, and in this he believes some deposits to take place. —The last paper in Part xi. is by Prof. Sayno, On a machine for drawing spirals, which he figures.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, Jan. 21.—On the anatomy of the connective tissues, by G. Thin, M.D.

Transparent animal tissues, when sealed up fresh in aqueous humour or blood-serum, by running Brunswick black round the edge of the cover-glass, undergoes a series of slow changes, by which, mostly within a period of two to five days, anatomical elements otherwise invisible become distinct. The paper is chiefly a record of observations made by this method. The author describes the results of its employment in the case of sections of the cornea, in which the stellate-branched cells are seen, after about twenty-four hours, to consist of masses of protoplasm, sharply defined. He has also similarly examined tendon neurilemma, fibrillary tissue, nerve-bundles, and muscular fibre; and compared the results with those arrived at by other methods of treatment.

Jan. 28.—On the atmospheric lines of the solar spectrum, illustrated by a map drawn on the same scale as that adopted by Kirchhoff, by J. H. N. Hennessey, F.R.A.S. Communicated by Prof. Stokes, Sec. R.S.

The spectroscopic observations described in this paper were made with instruments belonging to the Royal Society, and in accordance with certain suggestions which had been made to the author by a committee appointed in consequence of a letter of his to Sir Edward Sabine, president, dated 13th February, 1866. In view of his residence at a considerable height above the sea-level, and of the exceedingly clear atmosphere prevailing at some periods of the year, it was suggested that the locality was peculiarly favourable for a determination of the lines of the solar spectrum due to atmospheric absorption; and that for this purpose the solar spectrum when the sun was high should be compared with the spectrum at sunset, and any additional lines which might appear in the latter case should be noted with reference to Kirchhoff's map.

Accordingly the author set to work with the spectroscope first supplied to him, and in the autumns of 1868 and 1869 mapped the differences in question from the extreme red to D. These results appeared in the "Proceedings of the Royal Society" for June 16, 1870, and the map of the spectra, sun high and sun low, of the region in question forms Plate I. of the nineteenth volume.

The instrument first supplied to the author was found in practice to be of insufficient power to permit of ready identification of the lines seen in the spectrum of the sun when high with those represented in Kirchhoff's map; and a new spectroscope of greater power was supplied to him, which reached him at the end of the year 1871. Observations for a continuation of his map had in the mean time been taken with the old instrument in the autumns of 1870 and 1871, and the spectrum mapped from D to F, in continuation of the former map. But the new instrument proved so superior to the old, that the author determined to map the whole spectrum afresh from observations made with it, using the former maps merely as skeleton forms. The observations with the new instrument were carried on in the autumns of 1872 and 1873, and the map now presented is the result.

Observations were also made to ascertain whether any of the lines which came out when the sun is low, especially those which are also seen, but narrower and less conspicuous, when the sun is high, could be due, not to *specific* atmospheric absorption, but to the general weakening of the light, causing parts of the spectrum already weakened by *solar* absorption to appear dark when a *general* weakening of the light was superinduced, though they had appeared bright when the light was strong. For this purpose the spectrum of the sun when high, as seen in the usual way, was compared with the spectrum when the intensity was artificially reduced in various ways. The best comparison was obtained by taking advantage of a natural phenomenon. At Mussoorie, late in the autumn, a haze, visible at sunset, extends over the low country, and grows day by day in height, till it causes the sun virtually to set in haze while still 3° or more above the horizon, whereas in the clear season it is visible till it attains a depression of 1½°. The result of the comparison was, that none of the additional lines were discovered to have any other origin than selective atmospheric absorption.

Royal Horticultural Society, Jan. 20.—Scientific Committee.—Dr. J. D. Hooker, C.B., Pres. R.S., in the chair.—The Rev. M. J. Berkeley exhibited specimens of vine stems with large burr-like excrescences, which he suggested might be due to the attacks of a fungus like *Exobasidium*.—Mr. Worthington Smith exhibited a drawing of the microscopical appearance of the swellings on cucumber roots, confirming the accuracy of the observation long since made by the Rev. M. J. Berkeley, which connected these swellings with the presence of nematoid worms —probably an undescribed species of *Tylenchus*.—Prof. Thiselton Dyer called attention to a communication made to the Entomological Society by Prof. Forel, in which there was evidence to show that the Phylloxera had been introduced into vineries belonging to Baron Rothschild in the commune of Pregny, in the canton of Geneva, from England. The Phylloxera was discovered in England in 1863 by Prof. Westwood.—Prof. Thiselton Dyer also called attention to the statement in the *Daily News* (Jan. 19), that the Imperial Chancellor had introduced at the sitting of the Federal Council at Berlin on Jan. 18, an ordinance "prohibiting the importation of potatoes and the refuse and packing materials of potatoes from the United States," the object being to prevent the Colorado beetle from being imported into Germany. It was stated that the English Government had refused to prohibit the entry of American potatoes, on the ground that "it does not appear that the eggs or larvæ of the beetle have been or are deposited in the tuber of the potato." Mr. Andrew Murray described from his own observation the ravages effected by the beetle in Canada. Mr. McLachlan remarked that the beetle seems to have first spread from Mexico.—Prof. Thiselton Dyer stated with reference to the fruiting of *Hibiscus rosa-sinensis*—which had been said on the authority of Dr. Cleghorn not to take place even in India—that ripe capsules had been obtained after artificial fertilisation at Mauldslie Castle, Carluke, N.B., in 1871 and 1872, and plants raised from the seeds.—Dr. Masters exhibited specimens from Mr. Corderoy, of Didcot, of mistletoe parasitic on itself.

General Meeting.—Mr. W. A. Lindsay in the chair.—The Rev. M. J. Berkeley commented on the objects exhibited.—Mr. Bull showed a fine collection of Cycadaceous plants.—Mr.